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NEURAL NETWORK DECISION SUPPORT SYSTEMS
FOR THE DEPARTMENT OF DEFENSE:
AN EXPLORATION

by

Matthew Ludwig Laskowski

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Thesis Advisor: Tung Bui

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Neural networks have demonstrated the potential to deal with problems related to human cognition that to date have stymied researchers: problems that traditional rule and logic based artificial intelligence techniques have been unable to solve. The range of possible neural network applications is not yet fully understood. To date, research and development has tended to concentrate on a most impressive array of real-time embedded systems such as speech processors, target recognition and robotics control systems. The Department of Defense is a strong proponent of this technology. There is another side to the development and practical use of neural network applications. Inexpensive software is presently available that allows virtually any personal computer to function as a simulated neurocomputer. This thesis - presented in a personal computer based hypertext environment (a diskette is available) - reports the results of an exhaustive literature search and extensive hands-on experience with these tools and techniques.

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Neural Network Decision Support Systems
for the Department of Defense:
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by

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ABSTRACT

Neural networks have demonstrated the potential to deal with problems related to human cognition that to date have stymied researchers: problems that traditional rule and logic based artificial intelligence techniques have been unable to solve.

The range of possible neural network applications is not yet fully understood. To date, research and development has tended to concentrate on a most impressive array of real-time embedded systems such as speech processors, target recognition and robotics control systems. The Department of Defense is a strong proponent of this technology.

There is another side to the development and practical use of neural network applications. Inexpensive software is presently available that allows virtually any personal computer to function as a simulated neurocomputer.

This thesis - presented in a personal computer based hypertext environment (a diskette is available) - reports the results of an exhaustive literature search and extensive hands-on experience with these tools and techniques.

THESIS DISCLAIMER

The reader is cautioned that the computer programs and procedures described in this research have not been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that they are free of errors in concept, design and implementation, they cannot be considered validated. Any application of these methods is at the risk of the user.

The diskette containing the hypertext thesis may be copied for distribution provided that credit is given to the author. Due to copyright restrictions, the BrainMaker™ software - a backpropagation based neural network - is not included on the diskette. It is required only for the demonstration section of the thesis.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

This thesis is the result of an exhaustive literature search coupled with extensive hands-on experience with many of the methods described. Despite the fact that the seminal theories surrounding neural networks were published over thirty years ago, "connectionism" is an immature, but very vibrant, inter-disciplinary field. It encompasses cognitive theory, decision theory, logic, computer science, mathematics, statistics, operational analysis and more. Neural networks have the potential to deal with problems related to human cognition that to date have stymied artificial intelligence researchers. The intent of this thesis is not however, to wantonly proselytize the virtues of neural network techniques, but rather to inform a diverse readership of their characteristics and to encourage further experimentation.

B. SCOPE AND LIMITATIONS

Due to heightened interest, the corpus of theoretical information pertaining to neural networks is exploding. New methods are published monthly and older ones are continually being updated, refined and augmented. It is impossible to accurately synopsize such a volatile target. The idea of mimicking the function of the brain is by itself

fascinating, but even in its embryonic phase, this technology is capable of addressing some vexing real world problems. These problems range from the control of supersonic aircraft to gleaning information from diverse and complex data. It is in this latter domain that this paper will focus. A variety of diverse methodologies will be discussed, but only one problem solving approach will be examined in detail. Though personal computer based neural network simulations are not as fast as networks implemented directly in silicon, they are capable of supporting the efficient solution of problems that do not yield to statistical regression or optimization. In the course of this thesis a representative sample problem will be undertaken and the reader will be afforded the opportunity to interactively participate in its solution. This thesis is intended to stimulate further research and exploitation of these techniques, but it cannot hope to provide an authoritative procedural approach to their use.

II. ORGANIZATION

A. WHY HYPERTEXT?

This typewritten paper document serves only to introduce and explain the motivations and methods behind the actual thesis, which has been written in a PC-based hypertext medium (the diskette is available). Hypertext was deemed appropriate for the following reasons:

-it enhances the comprehensibility of the material;

-it appeals to a broad range of readers;

-it efficiently integrates text and graphics;

-it provides for an actual working demonstration of the neural network methods described;

-it simplifies duplication, distribution and storage of the document.

In order to understand the uniqueness and versatility of hypertext methods it will prove useful to contrast them with more familiar forms of printed text. This section briefly highlights the benefits of using hypertext. The reader interested in hypertext should examine Reference 1.

Traditionally text is, by its nature, sequential. The author assumes the responsibility for defining the order in which his work will be read. The reader proceeds systematically from word to word, sentence to sentence, and page to page until finished. Such a document is both

logically and physically linear. In contrast, hypertext is non-sequential. It not only permits, but also encourages the reader to decide the sequence that suits him. This is not altogether a new idea, as manual forms of hypertext have existed for centuries. An encyclopedia is a good example. Each article contains references to other related articles offering the reader the option to follow a "link" to peripheral information. In this case, navigation is part of the reading process.

A computer running appropriate software can readily implement these hypertext techniques. Using just the keyboard (or other input devices), the reader may meander through a document at his discretion, assimilating the material in an order and context that suit him. To prevent the reader from getting disoriented, navigational tools are in integral part of the document. He can follow a prearranged tour, locate his present position in the document on a graphic map, and recall all of the steps that he has taken, so that he can ascertain where he has been and how much of the document he has read.

It is not difficult to see the appeal of such a system: both the author(s) and the readers are afforded considerable flexibility. A properly designed hypertext document is capable of imparting at least as much information as conventional text and probably a lot more.

Granted, this technique has technological, practical and aesthetic advantages, but in many situations it is simply the most appropriate way to present the material. Perhaps more importantly, due to its compellingly interactive nature, readers tend to enjoy it. [Ref. 1]

B. HYPERWRITER!™ SPECIFICS

The main portion of this thesis, contained on the available computer diskette, was written using a commercially available hypermedia authoring software entitled HyperWriter!™. This authoring system offers the developer the ability to integrate text, graphics, video and audio as well as hypertext "links" into a single document. The result of using HyperWriter!™ on a body of information is an interactive document that a user can explore in a non-linear fashion.

For the author, this represents a departure from traditional techniques of composition. Disparate elements can be located where appropriate, and the reader can be provided access to this information along several very different paths. Composing a document using these methods has a decidedly different feel to it, one acknowledges the responsibility to not only inform the reader, but to guide him.

The HyperWriter!™ software contains features necessary for the creation of attractive and effective hypertext documents. It includes a text editor with a built in spelling checker, and the ability to import pre-existing text and graphics files. Most importantly, its companion "reader" software, HyperReader™, is licensed for unlimited distribution at no cost to the reader, much simplifying the process of distributing the document. [Ref.2]

C. DESIGN CONSIDERATIONS

Despite the freedom of choice that hypertext affords the reader, to some extent the author maintains the ability to influence the manner in which the document is read. If the author deems it important for the reader to view a particular portion of the text in its entirety, then it should be presented in that way. On the other hand, the reader can and should be encouraged to explore when sequence or cohesiveness is less vital. The reader's background knowledge of the subject area must be taken into account so that terminology can be used without the need to embed detailed explanations. Any confusing or ambiguous terms can be defined through a link, thus allowing the knowledgeable reader to avoid the tedium of reading descriptions of familiar terms, while the uninformed reader has free and ready access to those descriptions. This in turn effects the length of any given portion of the document. The individual portions can be made much more terse while still conveying all necessary information. Properly executed, the same information can appeal to a far wider readership.

Every effort must be made to establish meaningful conventions and to adhere to them consistently. In this thesis all links to graphic images are colored green, all references are red and any item with a rectangular box surrounding it leads to a link. In a document of this kind the reader will generally be presented with an overwhelming

amount of new information, consequently his interface to the material should become transparent to him and should not be allowed to intrude or to disconcert him. Figure 1 graphically illustrates the simplicity of the hypertext interface.

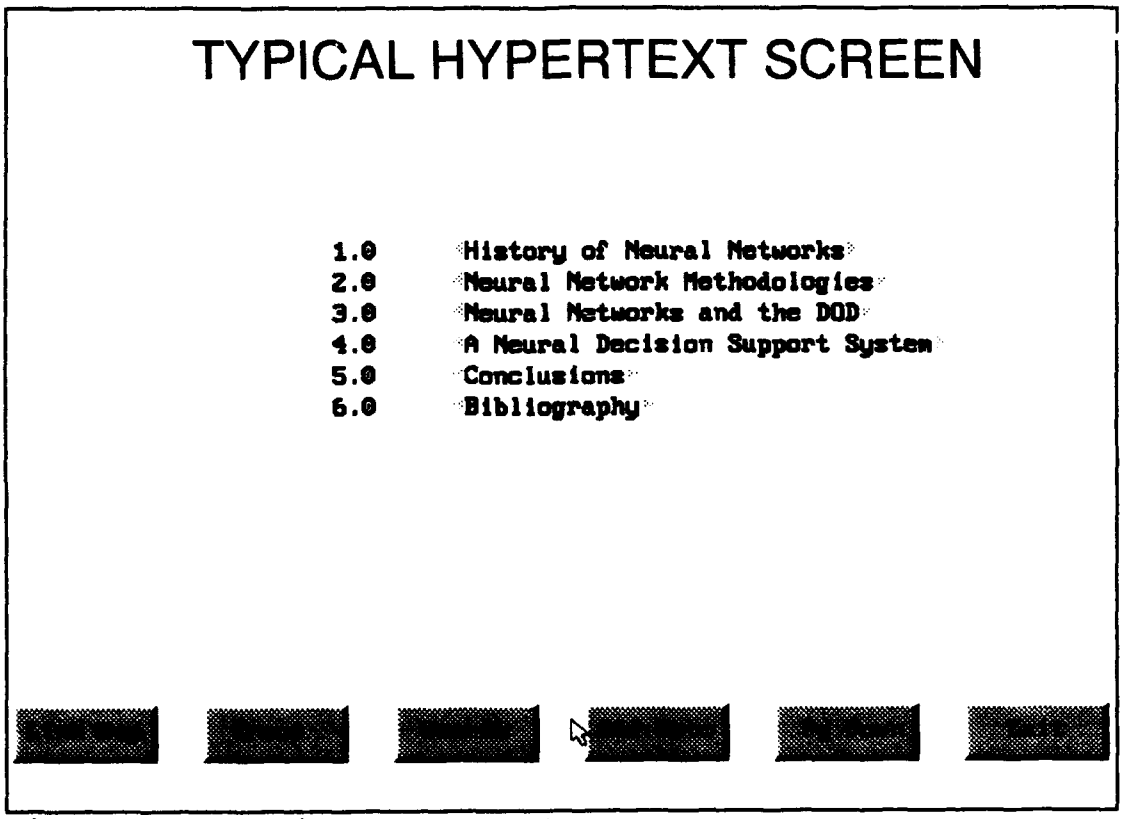

Figure 1 A typical hypertext screen

In the interest of conventionality, this hypertext document has been constructed to appear, at least in part, as a traditional typewritten research paper. Essentially, this means that the text is presented in a fairly linear fashion and all of the linkages extend from the text.

A more powerful alternative may be to organize the material visually, through the use of on-screen graphical images or maps. The links extending from these graphics would lead the reader to accompanying explanatory text. This method proved effective in some areas of this thesis, but the underlying design philosophy was generally to emphasize links from text to graphics.

D. SYSTEM REQUIREMENTS

This hyper-document is designed to be read on a typically configured personal computer.

Specifically the requirements include:

-IBM Disk Operating System (DOS) version 3.0 or later

-a color monitor supporting Expanded Graphics Array (EGA) or Video Graphics Array (VGA)

-a hard disk drive with approximately 2.5 megabytes of available storage space

-a MicroSoft™ compatible mouse

-a minimum of 520 kilobytes of available system memory

E. INSTALLATION

The distribution diskette is available free of charge. If you desire a copy please mail a formatted high density diskette along with sufficient return postage to:

Prof. Tung Bui, Code AS/BD
Naval Postgraduate School
Monterey, CA 93943-5000

An automated utility has been created to make the installation of this document as trouble free as possible. It is designed to copy the files from a high density (either 5 1/4 inch 1.2 megabyte or 3 1/2 inch 1.44 megabyte) floppy disk drive labeled A: to the hard disk drive labeled C:.

To install:

-insert the floppy disk in the A: drive

-type **A:** and press **Enter**

-type **INSTALL** and press **Enter**

-the program will instruct you to type **START** and press **Enter** to begin reading

Note: If your system's disk drives are not labeled in this way you must manually install the software. This will require you to create a subdirectory on the chosen hard disk, copy all of the files from the floppy diskette to that subdirectory, decompress the files and finally type START.

III. NEURAL NETWORK DECISION SUPPORT FOR THE DOD

A. SUMMARY (HYPERTEXT VERSION)

Neural network methods are simply too enticing to ignore. Despite their current popularity among some academics and much of industry, their widespread use is at best still a few years away. The groundwork has been laid, but further research must contend with a significant number of theoretical and practical issues. Nascent neural systems have been denounced as being "toy" solutions to "toy" problems. In part this is a valid criticism. At this evolutionary stage, most real-world problems remain slightly out of reach. This is at least partially due to the fact that real-world data is rarely maintained in a form readily suitable for neural network use. At issue too, are the networks' ability to grow in size and complexity, because most of the current architectures slow down unacceptably when presented with complex problems. Research in the area of hybrid networks is in its infancy, but it certainly offers tremendous promise for dealing with increasingly complex cognitive problems.

Another area of concern must be the hyperbole that surrounds neural networks. Virtually all of the commercial software simulation products are guilty of making some pretty outlandish claims. There is a very real danger that

the technology will be oversold and will subsequently disappoint and frustrate its user base. Rule based expert systems have set the historical precedent. The general population has been promised "thinking" computers for more than thirty years: the mounting disappointment has created a generation of skeptics. Perhaps this is a blessing in disguise. If neural networks survive this skepticism and scrutiny, they will be more likely to emerge as mature and useful systems.

There are immediate dangers if poorly designed and inadequately tested neural network applications are rushed into service. Such systems may glibly output dangerously incorrect answers. The question of legal liability has already been raised with regard to expert systems. Ethical questions will also arise regarding the invasion of personal privacy. Thoughtful policy guidelines and even legislation will eventually be required. In any event, a thoroughly conservative approach should be applied. Such an approach will demand both rigor and patience, but will provide the most lasting benefits.

In order for this technology to flourish, the future user population must be given a rudimentary education in its inherent capabilities. This will serve two purposes. First, it will sensitize potential users to the type and format of data that is most usable by neural network applications. No problem can be solved by a neural network if the relevant

data is insufficient. With a little bit of foresight, all future databases will be ripe for neural analysis. Secondly, if the data exists in the proper form, the users will clamor for new analytical tools.

In this era of federal fiscal austerity it may be necessary to divert research funding from other programs, perhaps even from some of the expensive real-time neural systems. Due to the almost unlimited spectra of applications, it may be possible to "piggyback" neural efforts onto existing projects. From a contractual point of view this would be desirable, because existing government software contracting methods don't readily apply to this technology. [Ref. 3]

The Department of Defense can and should continue to aggressively pursue neural network research with an emphasis on deployable systems. The conceivable benefits of this leadership are enormous.

The DOD should:

-Adopt (or create) a standard neural network development package suitable for the average personal computer user

-Formalize the application development cycle

-Create and man roving neural "tiger teams" with a charter to seek out potential application areas

-Establish an on-line neural "clearinghouse" using the Defense Data Network (DDN)

-Freely grant access to data for research purposes and make it available for transfer over the DDN

-Maintain existing expert systems for possible incorporation into hybrid systems

-Completely rewrite DOD-STD 2167A, to make contracting for the development and purchase of these applications feasible

-Examine this technology as a remedy for the ongoing software "crisis" because it involves no conventional (and expensive) programming

-Most importantly, begin educating potential users

B. TABLE OF CONTENTS (HYPERTEXT VERSION)

This synopsized Table of Contents is supplied in order to provide some measure of the scope of the hypertext document. It in no way captures the rich inter-relatedness of the hypermedia environment.

C. LIST OF FIGURES (HYPERTEXT VERSION)

IV. CONCLUSIONS

The promise of neural network approaches to complex real world problems has not gone unnoticed. Both the government and the civilian sector are vigorously pursuing its application. When compared to other areas of research, the level of funding required is minuscule. There are no guarantees of success, but the most relevant risk is not related to failure, it is failing to participate in future successes.

As a by-product of this research, it is clear that the hypertext authoring environment has proven itself ideally suited for publications of this kind. The commercial software tools currently available, in conjunction with the general proliferation of personal computers, make this approach eminently practical.

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2. Johnson, J.S., "HyperWriter," *PC AI*, pp. 46-7, March/April 1991.

3. Rock, D., and others, "AI and the Military: Time for a Standard," *AI Expert*, pp. 56-7, August 1990.

All of the references cited in the hypertext version of this document are available to the reader on-line and are therefore not presented here.

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